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Inside . . .

Sandia's robotic work cell conducts high-throughput testing 'in an instant'

Automation speeds up 3D-printed part testing, materials science data collection

By Mollie Rappe

Today with 3D printing you can make almost anything in a matter of hours. However, making sure that part works reliably takes weeks or even months.

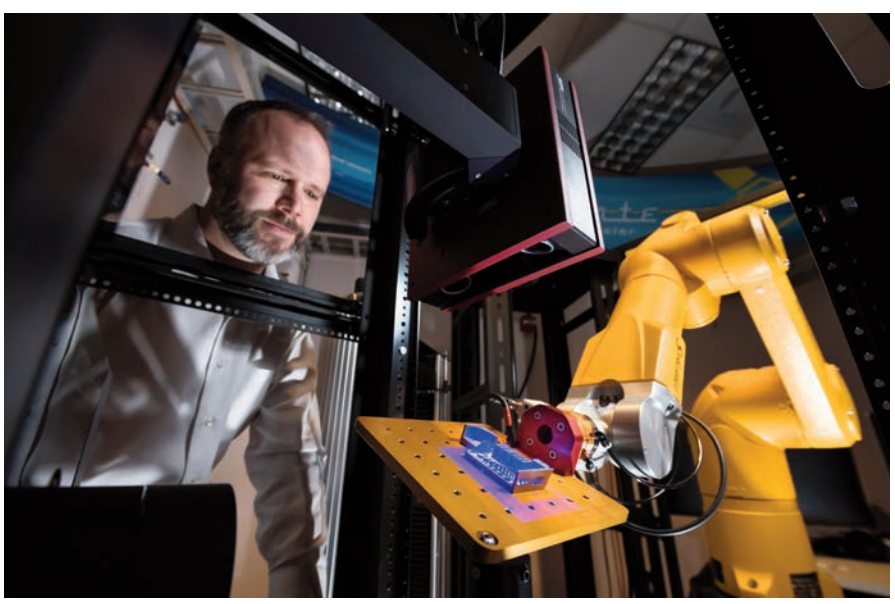
Until now.

Sandia National Laboratories has designed and built a six-sided work cell, similar to a circular desk, with a commercial robot at its center that conducts high-throughput testing to quickly determine the performance and properties of the part.

They call this flexible, modular and scalable system Alinstante, Spanish for "in an instant." Sandia is seeking industry partners to help expand or discover more uses for the new robotic testing system.

The technology to speed up qualification and testing was the result of Sandia materials scientist Brad Boyce's challenge in the spring of 2015. Brad was working on a Laboratory Directed Research & Development-funded project to improve the qualification of custom 3D-printed parts.

"In traditional manufacturing of metals, there's a lot of experience and finesse in process control to produce metals with uniform properties. When we went to laser manufacturing we had to take a step back and rethink qualification," he said.



Sandia materials scientist Brad Boyce watches as the Alinstante robotic work cell scans a 3D-printed part to compare what was made to the original design. This test part was devised to push the limits of 3D printing technology. The goal of Alinstante is to speed up the testing of 3D-printed parts and materials science research. (Photo by Randy Montoya)

Brad had already developed a machine for high-throughput tensile testing — pulling on an object until it snaps — but for this project he knew he needed a more general, flexible solution. He turned to Sandia's robotics group.

"Once we committed ourselves to automation, we realized that the barriers could be overcome," Brad said. "Yes, we invested some time and money, but the real challenge was getting ourselves out of the mindset of 'business as usual' to understanding that we need a faster solution."

Designing a modular, flexible work cell

The commercial robot sits in the center of the hexagonal work cell with up to six "petal" work stations around it. Each work station can have a different commercial or custom testing system, and the work stations can be swapped in and out depending on the kind of tests needed. Also, because of the

(Continued on page 4)

USSTRATCOM commander urges talk on nuclear weapons

National conversation critical for strategic deterrence, general says

By Michael J. Baker

It's time the country started talking about strategic deterrence and nuclear weapons again, said U.S. Air Force Gen. John Hyten, commander of U.S. Strategic Command, during a Sandia all-hands meeting in May as part of the National Security Speaker Series.

"In many cases, we have lost the art of discussing strategic deterrence," he said. "We don't talk about deterrence. We don't talk about what it takes to control an escalation scenario."

Hyten presented "A Warfighting Perspective," and after a short introduction by Labs Director Steve Younger, Hyten received a standing ovation.

"I'm not a Sandia person," Hyten responded. "I'm not a DOE person, but it does feel, as I'm walking around talking to people, I feel like I'm part of the family."

Hyten previously spoke at Sandia in 2015, when he was the head of Air Force Space Command. At the time, he had a growing interest in nuclear weapons, he told the audience at the Steve Schiff Auditorium and via video stream to Sandia/California and other Sandia locations.

"All of a sudden on Nov. 3, 2016, it became a very, very, very important part of my life; a sobering part of my life," he said of his reaction when he became commander of USSTRATCOM.

Air Force Gen. John Hyten addresses Sandians during an all-hands meeting on May 22 as part of the National Security Speaker Series. (Photo by Lonnie Anderson)

(Continued on page 4)

Riding bacterium to the bank

Sandia researchers tailor E. coli to efficiently and economically convert plants into renewable chemicals

By Jules Bernstein

What does jet fuel have in common with pantyhose and plastic soda bottles? They're all products currently derived from petroleum. Sandia National Laboratories scientists have demonstrated a new technology based on bio-engineered bacteria that could make it economically feasible to produce all three from renewable plant sources.

Economically and efficiently converting tough plant matter, called lignin, has long been a stumbling block for wider use of the energy source and making it cost competitive. Piecing together mechanisms from other known lignin degraders, Sandia bio-engineer Seema Singh and two postdoctoral researchers, Weihua Wu, now at Lodo Therapeutics Corp., and Fang Liu, have engineered E. coli into an efficient and productive bioconversion cell factory.

"For years, we've been researching cost-effective ways to break down lignin and convert it into valuable platform chemicals," Singh said. "We applied our understanding of natural lignin degraders to E. coli because that bacterium grows fast and can survive harsh industrial processes."

The work, "Towards Engineering E. coli with an Auto-Regulatory System for Lignin Valorization," was recently published in the Proceedings of the National Academy of Sciences of the United States of America.

Engineering a costly process into profitability

Lignin is the component of plant cell walls that gives them their incredible strength. It is brimming with energy, but getting to that energy is so costly and complex that the resulting biofuel can't compete economically with other forms of transportation energy.

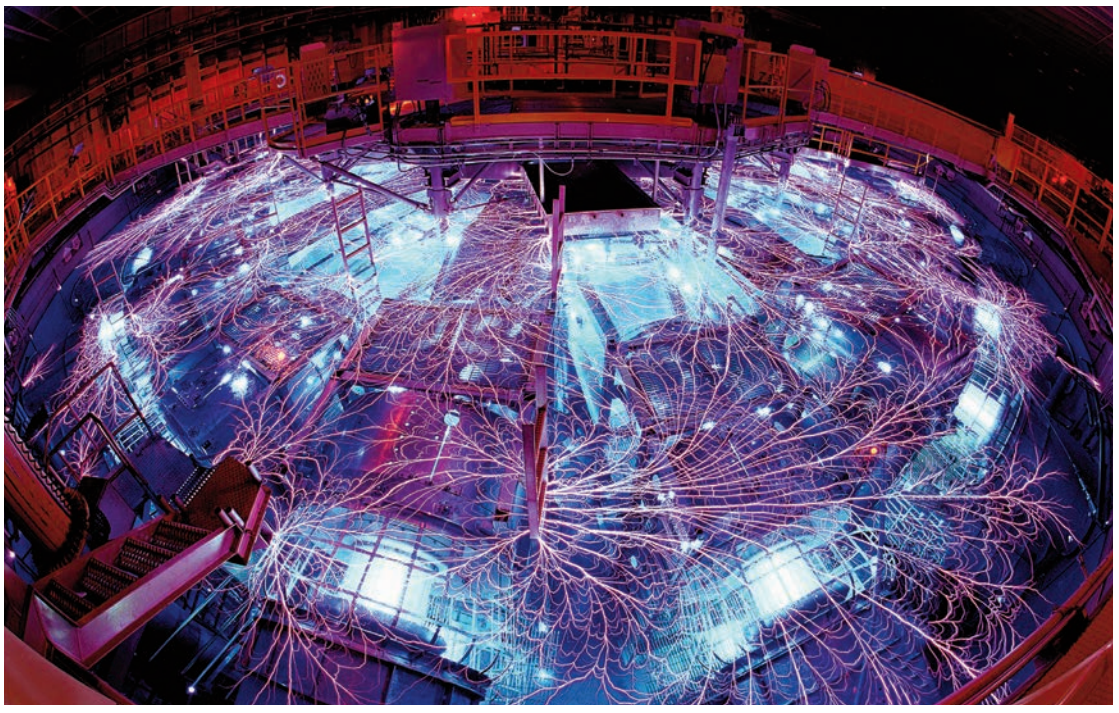
Once broken down, lignin has other gifts to give in the form of valuable platform chemicals that can be converted into nylon, plastics, pharmaceuticals and other products. Future research may focus on demonstrating the production to these products, as they could help bring biofuel and bioproduction economics into balance. Or as Singh puts it, "they valorize lignin."

(Continued on page 6)

Lab News Notes

Editor's Note: Lab News seeks guest columnists with observations on life at the Labs or on science and technology in the news and in contemporary life. If you have a column (500-750 words) or an idea to submit, please contact Jim Danneskiold, the acting editor.

Corporate Photojournalist Randy Montoya at the Z machine in 1998 when the iconic "Arcs and Sparks" photo was taken.



5 seconds at F/16, with a broken camera

For Sandians, President Truman's letter to AT&T on May 13, 1949, is their sacred text.

If they have a totem animal, it's that one-eyed, big-shouldered bird that watches over everything they do.

And they surround themselves with hallowed images, too: micrographs of molecules making seemingly impossible moves; pictures of amazing devices that would make Rube Goldberg gasp; incredibly detailed charts showing the progress of complex, multifaceted missions; even team portraits from days gone by.

"The fact of the star is in the burned-out hunk of charcoal spinning in deep space, but the truth of the star is in the stream of photons pulsating through the vacuum at light speed, slamming at light speed into the atoms of my retina, electrifying the optic nerve . . ."

— "The Gardening of Thomas D." by Rinde Eckert

But only one image has attained iconic status. Only one illustrates Sandia on walls and websites everywhere — Randy Montoya's startling photograph capturing the Z machine at work on a cool autumn (or hot summer or ...) in May 1998. Stand and stare at the immense blow-up of his picture at the entrance to Z, and soon the viewer senses something akin to a projection of the brain's neuronal activity on the back of the eyelids, an impossibly energetic, improbably all-encompassing light show.

It's an unusual photo. It shows the release for just 100 nanoseconds of roughly 200 trillion watts of x-ray energy, many times all the electrical power generated in the world at any given moment.

More mundanely, it's a partial view of roughly one-third of Z's surface as the machine actually fires, with the hood up.

Often referred to by its nickname, Arcs and Sparks, the image is ubiquitous, gracing the covers of physics textbooks, used and misused to illustrate countless technical documents and websites. It was even named one of National Geographic's 1,000 Greatest Images in 2004.

Randy had photographed the Z machine many times, but a discussion with former Sandia VP Don Cook inspired him to try something else.

"I told Don, I want to put a lens right down inside the target," he says. "I wanted to get away from showing a pattern and instead get a shot of lightning right up in your face. My management told me it was impossible.

"This weird thing called the internet was just taking off and I must admit I was inspired, seeing all these great photographers trying to make science more personal, trying to get people interested in the nuts and bolts of how people do science," he recalls.

"This was an actual experiment," he emphasizes. "Absolutely anything could happen."

Z was in its infancy then. But the pace of work was no less heated than today, with experiments, or shots, sometimes happening twice a day.

"The most important fact about being a photographer at Sandia is that people almost always become excited about showing off their work. They are just so eager to help."

Randy knew he couldn't use one of the Labs' new, fancy electronic cameras. The X-ray pulses from the Z machine would kill anything electronic. That was OK. Randy's an old-school photographer.

"I went down to talk to Art at Camera and Darkroom and I told him, 'I want to rent a camera, preferably a broken camera'," he recalls. The shopkeeper gave him a beat-up Nikon F, "a nice old camera. It shot color negative film and that gave me more latitude."

To trigger the second-hand camera, Randy scavenged 86 feet of surgical tubing — used to trigger leaf shutters on 4-by-5 cameras. Technicians helped him connect the tubing to a small air compressor so he could flip a switch to trip the shutter open for an exposure of approximately five seconds. He figured that was long enough to capture the light, since Z only fires for roughly about 100 billionths of a second.

Randy walked all around the huge machine with the crew until they discovered a spot where they could safely remove part of a walkway and mount the camera onto one of the a diagnostic pipes, aiming into the target area, the heart of the beast.

"I just clamped it on the pole and hoped it was pointing at something that would show up on the negative.

"You know, there's a fair amount of guessing to this. I used a small level after I'd clamped it and ran a roll of badly exposed film through there. There really wasn't much to adjust or fine-tune.

"I had no idea what would happen. It's a working facility," Randy says. "You lash everything down the best you can, but everything's banging and crashing."

Randy waited outside the chamber with the technicians, all of them focused on the loudspeakers — "10 seconds, nine, eight ..." — waiting for the moment when banks of generators would fire to generate 16 million amps, creating a fireball that for an instant would burn at more than 2 million degrees.

"As they were going through their countdown, we were pretty confident the camera would work," he recalls. "We just didn't know if we'd get anything."

The normal target retrieval, safety checks and extensive clean-up work kept the Z crew busy late into the evening.

In the morning, Randy drove over to Z to retrieve the camera, with no idea whether he'd captured anything at all.

"I went back the next day and it was gone. My heart sank."

The crew had carefully removed all of his equipment and put it in a box. When he developed the film, there it was.

One important fact that few non-engineers know about "Arcs and Sparks" is that — like an Avedon photo — it depicts the machine exactly as it was at the moment the shutter snapped, warts and all.

"All that lightning on the top is simply inefficiencies of the machine, because Z is designed to put all the electrical energy into the target," he explains. "It's kind of like a carburetor that isn't mixing the fuel efficiently so you get a big exhaust plume out of the muffler. In a way, I was capturing the backwash from the experiment because of those inefficiencies. Those were early days, and Z is far more efficient now."

It's a cliché voiced by artists all the time, but the photo, viewed by millions over the past 20 years, truly was a team effort.

"Anyone who has photographed PBFA-1, PBFA-2, Hermes — all the big machines — whether it was me or National Geographic, we've all plagiarized from the work of the technicians" who had shot it before, he says. "Even the equipment I used to trigger the camera was playing off ideas from the first technicians who tried to capture the image."

People ask Randy how many tries it took him to get the shot. "One," he tells them, and when photographers inevitably ask, he explains why it could never happen again because of all the equipment installed later. The surface is plated over to bear the weight of additional test instruments.

"Every time I go into a place like Z and do something, I'm interrupting people's work, so I try to work quickly," he says. Surveying the scene and the lighting, gauging the people and how they feel about their work and a plethora of other intangibles guide him.

"People know that what I do, I do it because I'm trying to help the Laboratories," he says.

— Jim Danneskiold

What happens when Z fires:

The Z machine uses electricity to charge large capacitors — structures designed to store an electric charge and release it almost instantaneously. These capacitors discharge to produce radiation and high magnetic pressures, which are used to study everything from nuclear weapons to planetary formation to fusion energy. When Z fires, powerful electrical pulses strike a target made of hundreds of tungsten wires. It's about the size of a spool of thread. The flow of energy through the wires dissolves them into plasma and creates a strong magnetic field that forces the exploded particles inward. The speed at which the particles move is equivalent to traveling from Los Angeles to New York — about 3,000 miles — in slightly less than one second. The particles then collide with one another along the z axis (hence the name Z machine), and the collisions produce intense radiation (2 million joules of X-ray energy) that heats the walls of the target to approximately 1.8 million degrees Celsius.

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DOE classifies Winalee Carter as 'excellent'

Honored with 2018 Classification Award of Excellence

By Michael Padilla

If you want to give a talk at a conference, have an official document reviewed, or submit a paper to a journal, Winalee Carter is the person nearly everyone at Sandia/California counts on to give the final stamp of approval.

In recognition of her exceptional service, Winalee last month received the Department of Energy's 2018 Classification Award of Excellence at the 53rd Annual Classification Officers Technical Program Review Meeting in Germantown, Maryland.

Recognized for improving the California classification program

Winalee was recognized for her "dedication to improving the classification program of the Sandia National Laboratories — California and throughout the DOE and the National Nuclear Security Administration."

In particular, she was recognized for revising all the major classification guides for Sandia/California's current stockpiled weapon systems and playing a major role on the team that developed the current classification guide for use control. Most recently, she resolved several classification issues related to the development and implementation of the W80-4 Life Extension Program. Winalee consulted with various subject matter experts and other classification offices to resolve many W80-4 issues.

Winalee said she is honored to receive the award, especially because the previous award winners include people she has admired and enjoyed working with.

"Being nominated for the award by the weapons groups means a lot to me," she said. "They do the largest percent of classified work at the site, so I spend much of my time supporting them."

She said it feels good to be recognized for the hard work, "even when things don't always get done as quickly as any of us would like."

Winalee Carter displays her DOE Classification Award of Excellence. (Photo by Brent Haglund)

Mike Hardwick, the California weapons center director took part in the nomination and said Winalee is very deserving of the recognition.

"Winalee provides a vital service to the nuclear weapons program," Mike said. "She understands nuclear weapon design and has years of experience with classification policy and rules. Without her guidance, we would not be able to steward the stockpile or execute modernization programs."

Background in weapon design work

Winalee came to Sandia in 1982 with a master's in mechanical engineering and spent her first 16 years conducting weapon design work. Twelve years into her career, there was a need for someone to handle the day-to-day work of the classification office for six months. She accepted the assignment and then returned to weapon design work. Three years later, the classification officer wanted to move back to Albuquerque.

"I had found, to my surprise, that I enjoyed the work," said Winalee. "I took the classification officer position in August 1998. It was so very different than the hardware design work that I loved, but I enjoyed it. I still enjoy the challenge."

Classification work changes over the years

During the past 20 years, there have been many changes in the California site classification office. In 1998, there were 48 derivative classifiers in California — almost entirely managers — and 385 requests for review and approval (R&A). All work was conducted via hard copies, which were routed to each reviewer. The California site now has 218 derivative classifiers — mostly technical staff — and some 1,400 R&A requests are routed via electronic workflow.

"When I started in the classification office, our work consisted almost entirely of nuclear weapons, and the only facility outside of the limited area was combustion research," she said. "Now we have branched off into many other programs and have four separate security areas, from the general access area to special programs."

On a typical day, the classification office reviews anything that is going to the public to assure it contains no sensitive information — classified or unclassified. The classification office also reviews all official SAND reports.

In addition, Winalee trains and authorizes derivative classifiers to understand and use the published classification guides so that they can properly classify the work around the site, including local weapon programs. Winalee also provides the final classification reviews for all security incidents and sends classification challenges up the NNSA/DOE chain to the DOE Office of Classification for final determinations.

Covering your BASES: California Seminar Series

Sandia *Exceptional service in the national interest* CaliforniaNews

Predicting disease with big data

By Jules Bernstein

The monthly Bay Area Strategic Engagement Seminars (BASES) series in California has been, by all accounts, a home run. The series gives staff a chance to learn from leaders in key Sandia-related fields, and most recently brought Stanford University Genetics Chair Michael Snyder to campus.

Snyder shared his vision for the future of medicine, in which big data sets from DNA sequencing, wearable electronic devices, bodily fluid analysis and other sources will help predict, diagnose and treat disease before symptoms ever appear.

"The way we're doing medicine now is all wrong," Snyder said. "We treat people when they're sick. We need to follow them when they're healthy."

Michael Snyder, Director of the Center of Genomics and Personalized Medicine and Stanford Chair of Genetics.. (Photo courtesy of Michael Snyder)

In his clinic, Snyder has been following more than 100 healthy people, measuring them every three months or more for the past four years. Regular profiling with new technologies has allowed him to discover early cancers in some patients and notably, diabetes and Lyme disease in himself.

New technologies for personal health profiling

The concept of obtaining baseline data about a patient to assess their health isn't new of course. It is normal for doctors to assess weight, blood pressure and such against previous measurements. What is new is the incredible depth to which people can now be sampled using new technologies.

Sequencing all 6 billion base pairs of DNA in a person's genome costs now costs less than $1,000, and is key to learning about conditions to which an individual may be predisposed. Snyder tracks DNA for his patients, as well as multiple other 'omes' – including their epigenome (how the genome is read and acted upon), proteome (proteins), transcriptome (all RNA molecules) and microbiome (microbes found in the gut, skin, nose, mouth and urine).

Add to this picture the massive amounts of health data that Snyder is able to pull from wearable electronics. Snyder uses eight different devices to continuously track everything from weight, skin temperature, exercise and sleeping patterns to heart rate, blood oxygen levels and radiation exposure. Snyder says even the most basic smart watch alone can collect up to 250,000 measurements per day.

Completing the picture are advances in mass spectrometry that allow the analysis of blood and urine to an extent not possible a decade ago. Taken together, the data enables medicine that not only can predict illness, but also personalize treatments.

Systems analyst Andrew Kosydar is excited by what he heard. "Professor Snyder's work at the fascinating intersection of health and big data represents the future of medicine. These advancements will change the approach to medicine in this country from being primarily reactive to proactive," he said.

Computational scientist Kunal Poorey was similarly energized. Kunal's work has explored the use of data science on multi-omics data sets for early detection, as well as the correlation of diseases and the microbiome. "The most effective medical interventions vary from person to person. This is the future of medicine, and definitely a topic I want to work on in the near future," Kunal said.

> *"The way we're doing medicine now is all wrong. We treat people when they're sick. We need to follow them when they're healthy."*
>
> **— Michael Snyder**

Next at bat for BASES

The BASES series was originally the brainchild of Sheryl Hingorani, Jason Reinhardt, and Michael Nacht. Its goal is bringing thought leaders from institutions around the Bay Area to the California site to engage on national security topics and inject their thinking back into Sandia by establishing long-term relationships.

Since the inaugural March 2016 session in which the University of California, Berkeley's Sol Hsiang spoke on climatological threats to peace and prosperity, talks have covered topics ranging from the search for life on other planets to analysis of North Korea's nuclear capabilities. Video of the talks is always available for viewing on Sandia's BASES website.

Coming up next for BASES on June 26, professor Daniel Sperling of the University of California, Davis, will offer a seminar on sustainable transportation, "Three revolutions: automation, electric vehicles and ride sharing." He'll explore the opportunities and the risks of these disruptive innovations, and what they will likely mean for public policy, mass transit and the automotive industry.

In 2013, Sperling received the Blue Planet Prize from the Asahi Glass Foundation, which has been described as the Nobel Prize for environmental sciences. Those interested in meeting him before or after his seminar, contact Andrew Kosydar 925-667-1057 or Anthony Juarez 925-294-6210.

Robotic work cell

(Continued from page 1)

hexagonal shape, multiple petals can be combined in a honeycomb-like structure. That allows handoffs from petal to petal to provide almost limitless testing scalability.

Sandia mechanical engineer Ross Burchard led the design of the work cell. In 2016, Ross and an intern explored many different physical configurations before settling on the hexagonal petal design.

"My challenge was: How do you come up with a work cell with one robot and multiple testing stations that's also modular and scalable?" Ross said. Once the configuration was selected, Ross and his team built the first work cell. They adapted commercially available hardware wherever possible for efficiency and to save money.

In addition to constructing the hexagonal floor plate and pedestal for the commercial robot, the team installed safety light curtains wherever a person and the robot might interact. The light curtains are set up so that if a person reaches into the work cell, or if the robotic arm reaches out of the work cell, the light beam is broken and the robot automatically stops.

"Safety is always our No. 1 concern," said Tim Blada, the roboticist who is leading the design of the software interface. "Every line of code we write, every piece of mechanical fixturing we do, is always safety first. 'How is this safe? Can I do this without risking any injuries?'"

Rapid, automated testing with an easy-to-use modular user interface

By the end of the summer, Tim hopes to have a user interface that will allow a non-expert to place their parts on a tray in the parts rack, select a few tests and get their data automatically. The software architecture also needs to be modular so new modules and tests can be added easily, he said.

The prototype Alinstante work cell only has two testing stations and a rack where users can place their parts. The first station is an off-the-shelf structured light scanner that can convert a scan into a 3D model for direct quantitative comparison to the original intended design. The second station is a load frame for testing physical properties, such as tensile and compression testing, which is pushing on an object until it crunches.

Next, the team wants to add a laser-induced breakdown spectrometer to Alinstante, Ross said. This test would be particularly useful for determining the batch-to-batch consistency in the chemical composition of parts in a minimally destructive manner.

"Sandia has testing labs that can perform all of these tests, however it takes a few weeks to schedule each of them, which can add up to one or two months of testing. Alinstante can reduce the scheduling burden for the testing, greatly speeding up the turnaround time," Ross said. Alinstante also reduces the chance for human error and produces data that is more consistent and reproducible than human testers.

'Scratching the surface' of prototype testing and materials discovery

"Right now, Alinstante is really just scratching the surface of what it could be," Brad said. "We could integrate the printer, processing systems — such as a heat-treat oven or a grinder — and many other post-processing tests."

X-ray tomography, corrosion testing and density measurements are just a few examples of the tests the team would like to add to Alinstante.

Tim added, "Alinstante can be used for rapidly prototyping things or for small-batch manufacturing. This would be useful for any small business or industry where they're making small batch parts and they need to test them or even package them."

The Alinstante team is looking for partners to support the development of new modules that would meet its rapid testing, prototyping or research and development needs, Brad and Tim said.

As a roboticist, Tim is looking forward to putting Alinstante's endurance to the test. "In theory you could run this thing forever, if you had enough parts," he said.

As a materials scientist, Brad is looking forward to being able to use Alinstante for rapid materials discovery and for foundational advances in alloy performance and reliability.

But even before this vision becomes reality, Alinstante can provide significant benefits. Brad said, "Friday afternoon you tell the 3D printer 'I want you to print this part 10 different ways and then go test each one.' You come to come back Monday morning and Alinstante tells you which process was the best. Let the robot do all the logistics work and get the human out of the loop except for making the important engineering decisions."

Hyten visit

(Continued from page 1)

Confronting the threat

As head of USSTRATCOM, Hyten oversees one of the 10 unified combatant commands under the Department of Defense and commands the nation's strategic forces responsible for deterring strategic attack. USSTRATCOM provides a range of capabilities and options for the president and secretary of defense.

"As we walk through the various challenges that we have in dealing with these problems, in dealing with the adversaries that we face, we realize that nuclear capabilities are the backstop of everything that we do; and if we don't get that right, everything else is going to be a problem," Hyten said. "The strategic response includes space and cyber, but it has to start with the nuclear capability."

The revamping of the Nuclear Posture Review was necessary to confront threats from the nation's current adversaries by strengthening those capabilities, he said.

"I like it because it's elegant in its simplicity," Hyten said. "The Nuclear Posture Review says, 'here's the threat.' We have to modernize. We have to modernize the platform, plus the weapons, plus the infrastructure and the nuclear command and control piece. It says it right there very simply and why."

U.S. adversaries are getting better, he said, and that drives the need not only to modernize, but to build two supplemental capabilities: a small number of low-yield nuclear weapons and sea-launched cruise missiles.

"It's de-escalatory," Hyten said. "Now, an adversary, Vladimir Putin in particular, will have to look before he decides to use a low-yield nuclear weapon on a battlefield and realize if he does that the United States has the ability right now — not in 24 hours; not in 12 hours, but right now — to respond to that use, and there's nothing he can do about it. That is a deterrent, plain and simple."

Gen. John Hyten, left, speaks with Associate Labs Director Michael Burns as they walk between meetings at Sandia National Laboratories on May 22. (Photo by Lonnie Anderson)

Gen. John Hyten addresses Sandians during an all-hands meeting on May 22 as part of the National Security Speaker Series. (Photo by Lonnie Anderson)

Sandia's importance to the mission

Hyten said talking about nuclear weapons and deterrence in a range of venues will bolster awareness of the critical work at Sandia and other national labs.

"It's important that we have a national conversation," he said. "It doesn't matter where you come down on nuclear weapons, when that becomes part of the public lexicon, what happens is that all of a sudden the role of the national laboratories is understood again."

Sandia must succeed with its work for Hyten and those he commands to do their jobs effectively and for deterrence to work, he said.

"You've got to make sure that our weapons are always safe, secure, reliable and effective, that our adversaries know that," he said.

"When I look at this room, what I see is maybe what people in Washington don't see the same. I see the leading element of research and development in the strategic aspects of our nation in our national labs. … You're where deterrence starts, continues and, if we ever have to go down that path, ends," he said. "So, I just want to stand up in front of you and say thank you. Thank you for everything you do for our country; everything you do for my command."

Members of the workforce can access to Gen. Hyten's talk on Sandia's Corporate Streaming Library.

Who is General Hyten?

Gen. John Hyten is commander of U.S. Strategic Command, one of 10 unified commands under the Department of Defense. USSTRATCOM is responsible for the global command and control of U.S. strategic forces to meet decisive national security objectives, providing a broad range of strategic capabilities and options for the president and secretary of defense.

Hyten attended Harvard University on an Air Force Reserve Officer's Training Corps scholarship, graduated in 1981 with a bachelor's degree in engineering and applied sciences and was commissioned a second lieutenant. Hyten's career has included assignments in a variety of space acquisition and operations positions. He served in senior engineering positions on both Air Force and Army anti-satellite weapon system programs.

The general's staff assignments include tours with the Air Force Secretariat, the Air Staff, the Joint Staff and the Commander's Action Group at Headquarters Air Force Space Command as director. He served as mission director in Cheyenne Mountain and was the last active-duty commander of the 6th Space Operations Squadron at Offutt Air Force Base in Nebraska. In 2006, he deployed to Southwest Asia as director of Space Forces for Operations Enduring Freedom and Iraqi Freedom. Hyten commanded the 595th Space Group and the 50th Space Wing at Schriever Air Force Base in Colorado. Prior to assuming command of Air Force Space Command, he served as the vice commander of Air Force Space Command.

SOURCE: U.S. Strategic Command website

International corrosion society elects first Sandia fellow

Scientist devises unbearable sauna to solve nuke waste problem

By Troy Rummler

A decade ago, while studying potential corrosion of containers for the proposed Yucca Mountain nuclear waste repository in Nevada, Sandia materials scientist David Enos designed an intricate solution to a sticky problem.

Computer simulations showed the likelihood of unusually high heat and humidity deep inside the repository. Temperatures would rise above 200 degrees Celsius (392 degrees Fahrenheit), and the environment would be nearly pure steam; the corrosion science team he led had no way of recreating those conditions in the lab.

David had an idea. He rigged a steam generator to pipe directly into a sealed test chamber inside the belly of an oven, creating what may be the world's smallest and most unbearable sauna.

With that, he demonstrated that protective barrier materials for the waste containers would hold up in the intense environment. He later used the same system to evaluate storage containers used for spent nuclear fuel across the country.

First Sandian elected

The Yucca Mountain research and other innovative solutions earned David election as a fellow of NACE International, the chief professional society for corrosion engineering. He is the first Sandia employee to receive the honor.

The organization cites David's "significant contributions to corrosion science and engineering for protecting materials in complex environments, his leadership and for mentoring a number of students in the field of corrosion."

Wahid Hermina, David's senior manager, said "Corrosion is a critical degradation mechanism for our nuclear weapons stockpile since there are many corrosion processes, and weapons are fielded for decades in diverse environments. David is a key player for understanding corrosion mechanisms and how we can mitigate them."

The need to understand corrosion and related environmental degradation processes is more pressing at Sandia, which designs more than 95 percent of the nonnuclear components of nuclear weapons, than in other industries. If a consumer electronic "dies in five years, you don't even want that device anymore. You get a new one," said David. "We obviously can't do that. When Sandia builds a device, we need it to last for 30 years, and sometimes even longer."

Watching electronics corrode

On another assignment, David developed an advanced optical system to record images of corrosion as it grows over time in exacerbating conditions without having to remove the sample from the test chamber, protecting it from contamination. This device allowed him to watch the processes that degrade materials in a whole new way and led to a new theory that finally explained the mechanism of a type of corrosion called sulfidation on electronic connectors.

"David has an amazing eye for details and has helped solve a wide range of technical problems both inside and outside of the field of corrosion science," said Coby Davis, David's manager. "This broad exposure combined with an impressive memory allows David to see opportunities and connections between problems that others will frequently overlook."

David has for many years been an active member of the society, formerly called the National Association of Corrosion Engineers. He enjoys the opportunities the society gives him to help students access scholarships, classes and high-quality professional experiences. This year, he chaired the student poster session at the organization's annual conference.

Sandia National Laboratories researcher and NACE fellow David Enos (Photo by Randy Montoya)

"We try to provide venues where students can present their work, and we make sure each student has the chance to engage with technical experts about corrosion science and engineering, to discuss their research with them, respond to questions and just get some fresh eyes on their work," David said.

Fellows are a broad group of technical and professional leaders who serve as advisers to the association. As a fellow, David will serve as an expert resource both inside and outside the organization — potentially helping people from around the world with new and challenging corrosion issues that he has never seen.

And that's something he says he's very excited about.

DOE visit highlights Sandia energy work with Indian groups

Meeting discusses the state of STEM education, employment in Indian country

By Stephanie Holinka

Sandia recently hosted visitors from the DOE Indian Country Energy and Infrastructure Working Group and informed ICEIWG members, DOE officials and intergovernmental and contracted partners about Sandia's unique role in energy research.

The ICEIWG is comprised of DOE representatives, tribal leaders and their technical staffs who identify opportunities and obstacles to building energy capacity and related infrastructure development in Indian country.

Attendees Kevin Frost, DOE deputy director, Office of Indian Energy Policy & Programs and Doug Little, deputy assistant secretary, Intergovernmental and External Affairs, joined Sandra Begay, Sandia's Indian Energy program lead, who updated the tour participants on the state of STEM education in Indian Country.

"Indian Country faces many challenges in developing energy infrastructure and the advanced technical workforce required to support such infrastructure," says Sandra.

American Indians/Alaska Native students have the lowest overall graduation rate among any minority group. Only a small percentage of kindergarten students will go on to earn a bachelor's degree.

American Indians/Alaska Natives are also under-represented in science and engineering at the bachelor's, master's and doctoral levels. Fewer than half attend a public high school where the full range of mathematics and science courses are offered. Although they make up 1.2 percent of the U.S. population, they represent only 0.4 percent of all engineering bachelor's degree recipients, 0.3 percent of the engineering workforce (just 0.07 percent of those are women) and 0.1 percent of all engineering faculty.

Energy researcher Sig Gonzalez led tour members though Sandia's Distributed Energy Technology Lab, describing Sandia's work on utility-scale battery challenges and on standalone residential devices.

Systems engineer Bruce King discussed solar energy and grid integration work at Sandia's Photovoltaic Systems Evaluation Lab and the work Sandia does as the lead on DOE's Regional Test Center Program.

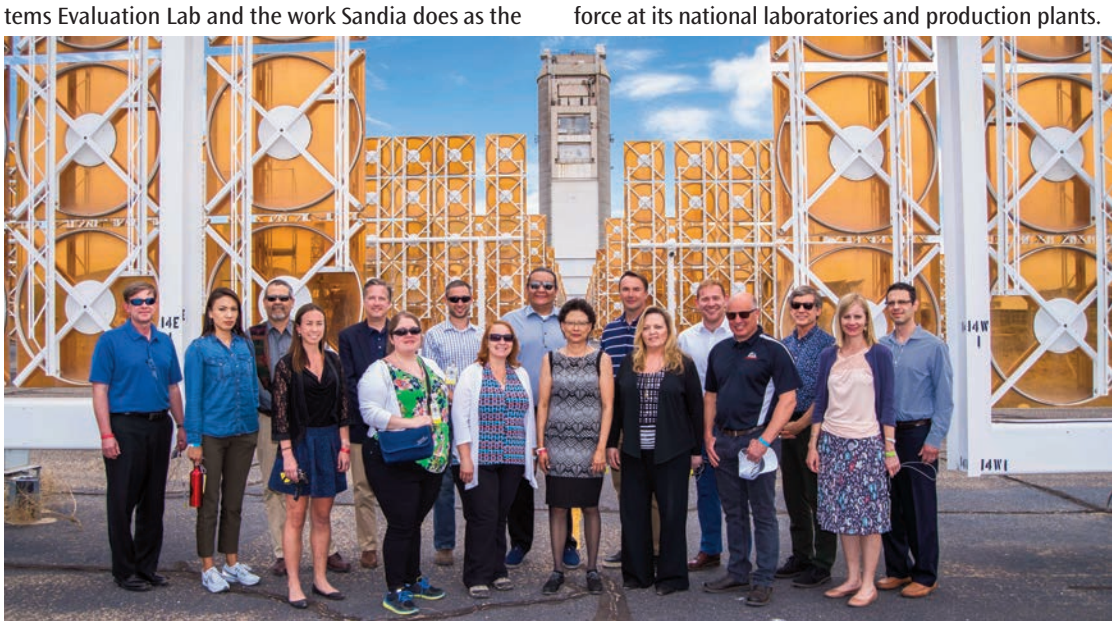
Optical engineer Julius Yellowhair led visitors through Sandia's National Solar Thermal Testing Facility and discussed Sandia's ongoing falling particle receiver research, part of Sandia's proposed design for a high temperature concentrating solar power pilot plant.

Managers Abraham Ellis and Lori Parrott shared an overview of Sandia's Alaska research, including work supporting Alaskan resilience against natural disasters and the harsh environment. Sandia also studies the suitability of renewable energy and microgrids for the Arctic environment, flies tethered balloons and drones to measure atmospheric temperatures and collaborates with other researchers on satellite sensing, detection and nonproliferation work.

Power electronics researcher Stan Atcitty led visitors through Sandia's energy test facilities, including the Energy Storage Analysis Laboratory and the Energy Storage Test Pad/Energy Storage Analysis Lab.

Stan says Sandia's work also is funded by the NNSA's Minority Serving Institute Partnership Program, which pays for a three-year project to enhance research and education at tribal colleges and universities in advanced manufacturing and funds summer students in technical projects. The program also seeks to develop needed skills and talent for NNSA's enduring technical workforce at its national laboratories and production plants.

Power electronics researcher Stan Atcitty leading members of the DOE Indian Country Energy and Infrastructure Working Group at Sandia's Energy Storage Test Pad. (Photo by Randy Montoya)



Members of the DOE Indian Country Energy and Infrastructure Working Group, DOE Indian Energy leaders and staff who work with Sandia optical engineer and Sandia Indian Energy Program lead Sandra Begay (center front) pose at Sandia's National Solar Thermal Testing Facility. (Photo by Randy Montoya)

SANDIA SCIENTISTS Seema Singh, left, and Fang Liu hold vials of fermentation broth and vanillin, which are critical for turning plant matter into biofuels and other valuable chemicals.

(Photo by Dino Vournas)

Bacterium

(Continued from page 1)

Solving three problems: cost, toxicity and speed

Singh and her team have solved three problems with turning lignin into platform chemicals.

The first was cost. E. coli typically do not produce the enzymes needed for the conversion process. Scientists must coax the bacteria into making the enzymes by adding something called an inducer to the fermentation broth. While effective for activating enzyme production, inducers can be so costly that they are prohibitive for biorefineries.

The solution was to "circumvent the need for an expensive inducer by engineering the E. coli so that lignin-derived compounds such as vanillin serve as both the substrate and the inducer," Singh said.

Vanillin is not an obvious choice to replace an inducer. The compound is produced as lignin breaks down and can, at higher concentrations, inhibit the very E. coli working to convert it. This posed the second problem: toxicity.

"Our engineering turns the substrate toxicity problem on its head by enabling the very chemical that is toxic to the E. coli to initiate the complex process of lignin valorization. Once the vanillin in the fermentation broth activates the enzymes, the E. coli starts to convert the vanillin into catechol, our desired chemical, and the amount of vanillin never reaches a toxic level," Singh said. "It autoregulates."

The third problem was efficiency. While the vanillin in the fermentation broth moves across the membranes of the cells to be converted by the enzymes, it was a slow, passive movement. The researchers looked for effective transporters from other bacteria and microbes to fast track this process, Wu said.

"We borrowed a transporter design from another microbe and engineered it into E. coli, which helps pump the vanillin into the bacteria," Liu said. "It sounds pretty simple, but it took a lot of fine tuning to make everything work together."

Engineering solutions like these, which overcome toxicity and efficiency issues, have the potential to make biofuel production economically viable. The external inducer-free, auto-regulating method for valorizing lignin is just one way that researchers are working to optimize the biofuel-making process.

"We have found this piece of the lignin valorization puzzle, providing a great starting point for future research into scalable, cost-effective solutions," Singh said. "Now we can work on producing greater quantities of platform chemicals, engineering pathways to new end products, and considering microbial hosts other than E. coli."

SOLAR SYMPOSIUM

Sandia hosted the 2018 Photovoltaic Systems Symposium May 1-3 in Albuquerque. About 155 participants from industry, the national laboratories and government attended, including Charlie Gay, the director of the Department of Energy's Solar Energy Technologies Office. Gay discussed DOE's goals for higher efficiency, lower cost and more resilient solar energy in the U.S., focusing on the technology advances needed for photovoltaics, concentrating solar power, energy storage, power electronics and grid integration.

Photos by Lonnie Anderson

PLANNING FOR THE FUTURE — Josh Stein, a Sandia systems engineer, presented 'The disruption of future PV developments,' which focused on the need for the solar industry and researchers to be able to characterize and model the next wave of photovoltaic products, such as solar roofing, solar ships and trains, solar roads, lightweight photovoltaics, internal tracking, adaptive shade response and more. Sandia's Bruce King, Cliff Hansen, Katherine Klise and Laurie Burnham also presented.

SANDIA CLASSIFIED ADS

MISCELLANEOUS

EXECUTIVE DESK, L-shaped, w/lateral filing cabinet, barely used, will split if needed, $900/pr. Parker, 505-944-5371.

YOUNG AT HEART CHICKEN & WAFFLES DINNER, Sandia Baptist Church, June 15, 5:30 p.m., $15. Johns, 858-3009.

AUDIOPHILE SPEAKERS, Vandersteen 2C, moderate usage, $300. Chow, 505-286-2570.

CAMPER SHELL, insulated, outside dimensions 80" x 95", excellent condition, photos available, $250. Hanks, 505-249-1931.

CHILDREN'S BEDROOM SET: full frame/mattress, dresser, nightstand, white, $350; Graco Lauren 4-in-1 convertible crib, white, w/Sealy foam-core mattress, $100. Miller, 510-299-0689.

TIMESHARE, Winter Park CO, sleeps 6, July 27-Aug. 3, $600/wk. Buck, 353-2667.

GENTLY USED FURNITURE: living room set; coffee table; entertainment center; king mattress; dresser; price negotiable. Frohn, 505-793-7570.

DOUBLE STROLLER, BOB Revolution, 2013, w/handlebar console & infant car seat adapter, orange, $400. Shah, 512-809-1038.

PUZZLE, 3000-pc., by Ravensburger, Germany, "Magic Mountain", unopened box, 48" x 32", $20. Wagner, 505-504-8783.

ARLO CAMERA KIT, original version, 2 cameras, hub, silicone camera sleeves, only needs camera mounts, $120. Cordero, 505-803-1576.

EXERCISE EQUIPMENT: Epic View 550 treadmill, excellent condition, $400; Bowflex Elite trainer, w/leg curl attachment, good condition, $250; Schwinn 215P recumbent bike, excellent condition, $150. Schneider, 505-270-4056.

SINGLE ELECTRIC OVEN, Whirlpool true convection, hardly used, excellent working condition, sells for $1,000, asking $390. Fulcher, 505-974-8670, after 5 p.m.

COFFEE TABLE, multicolored dark slate, 4' x 2-1/2', excellent condition, $300; cycling shoes, men's size 8-1/2, Shimano sandals, new/unused, paid $119, asking $40. Drebing, 293-3335.

5TH WHEEL HITCH, Reese 16K w/Kwik slide, rails for Chevy, $500. Schmitt, 505-281-6002.

TRANSPORTATION

'11 COROLLA SPORT, manual, silver, 55K miles, $8,000. Sapp, 505-377-0801.

'58 MG MGA, comprehensive body off restoration, no rust, rebuilt MGB motor, most parts replaced, $19,500. Baumann, 505-239-9180.

'08 HONDA ACCORD, standard, AC, 6 airbags, other safety features, 60K miles, great shape, $9,500. Cochran, 842-1528.

'13 FIAT 500 ABARTH TURBO, 5-spd. manual, loaded, 32K miles, great condition, $11,000. Swartz, 505-818-0722.

'74 260 Z, AT, AC, original owner, excellent condition, one of a kind NM Z car, $10,000. Gurule, 505-318-0140.

How to submit classified ads

DEADLINE: Friday noon before week of publication unless changed by holiday.
Submit by one of these methods:
- **EMAIL: Michelle Fleming (classads@sandia.gov)**
- **FAX: 844-0645**
- **MAIL: MS 1468 (Dept. 3651)**
- **INTERNAL WEB: From Techweb search for 'NewsCenter', at the bottom of that page choose to submit an ad under, 'Submit an article'. If you have questions, call Michelle at 844-4902.**

Because of space constraints, ads will be printed on a first-come basis.

Ad rules

1. Limit 18 words, including last name and home phone (If you include a web or e-mail address, it will count as two or three words, depending on length of the address.)
2. Include organization and full name with the ad submission.
3. Submit ad in writing. No phone-ins.
4. Type or print ad legibly; use accepted abbreviations.
5. One ad per issue.
6. We will not run the same ad more than twice.
7. No "for rent" ads except for employees on temporary assignment.
8. No commercial ads.
9. For active Sandia members of the workforce, retired Sandians, and DOE employees.
10. Housing listed for sale is available without regard to race, creed, color, or national origin.
11. Work Wanted ads limited to student-aged children of employees.
12. We reserve the right not to publish any ad that may be considered offensive or in bad taste.

'08 BMW X5 3.0si, AWD, champagne, brown leather, 22/26-mpg hwy., no accidents, 79K miles, excellent condition, well below book, $9,800. Dwyer, 505-249-6935.

'11 HYUNDAI SONATA HYBRID, leather, 40-mpg hwy./35 city, 104K miles, clear title, no accidents, new tires, excellent condition, $8,999. de la Fe, 505-459-4685.

RECREATION

KAYAKS, by Old Town, Rush 9'6" sit in, $200; Dirigo 120 Angler w/rod holders, anchors, etc. $600. Fromm-Lewis, 505-220-5772.

REAL ESTATE

3-BDR. HOME, Las Cruces, near NMSU, search Zillow.com listing: 2326 La Senda 88011, $169,600. Fitzpatrick-Fletcher, 575-448-1212.

WANTED

HOST FOR INTERNATIONAL HIGH SCHOOL STUDENT, w/AFS. Hiebert-Dodd, 296-1158.

Kirtland Air Force Base Reveille and Retreat Reminder

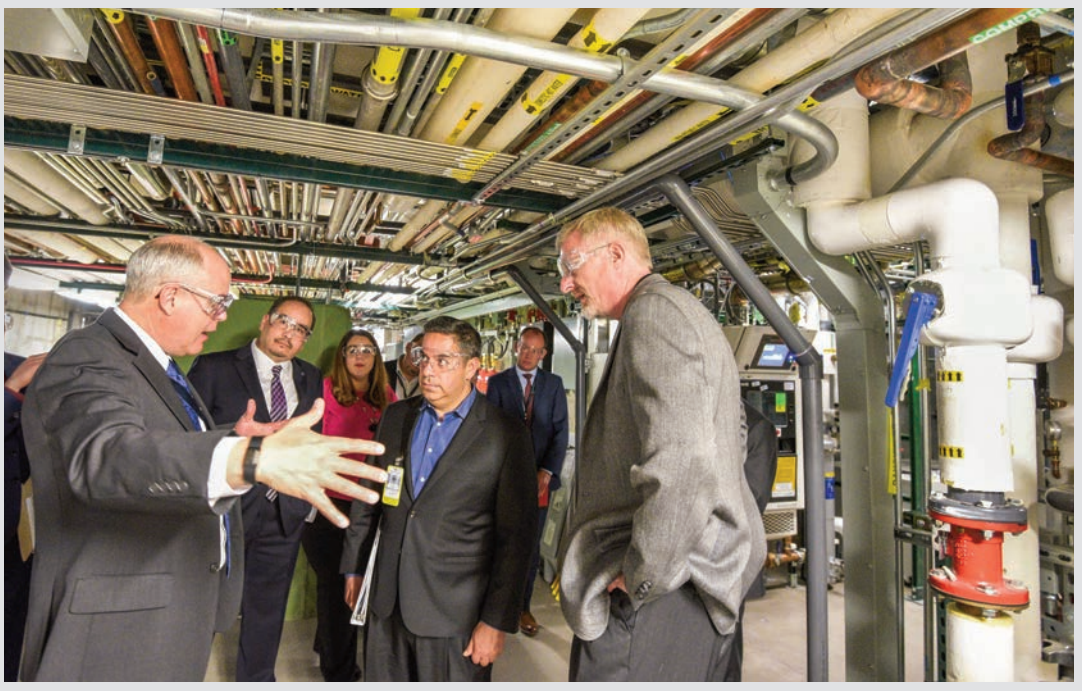
When driving on Kirtland Air Force Base, all civilian and military personnel should come to a complete stop for reveille at 7 a.m. and for retreat at 5 p.m. during the broadcast of "To the Colors" and "The Star-Spangled Banner," respectively. Anyone outside should stop and face the sound of the music or a flag and motorists should pull to the side of the road until all music has finished playing.

Reveille and retreat ceremonies serve a twofold purpose. They signal the beginning and ending of the official duty day and serve as ceremonies for paying respect to the flag and those who serve it.

Retiree deaths

Josephine Sandoval (age 84)	January 1
Barbara Pass (65)	January 17
Dennis Chavez (89)	February 24
Melton Rushing (96)	February 27
Linda Cusimano (77)	February 28
Wendland Beezhold (78)	February 28
Joan Keith (89)	March 7
Charlie Monroe (90)	March 9
Richard Ashmore (96)	March 9
Eleanor Slutts (94)	March 11
Larry Wilhelm (79)	March 12
Lynn Barker (90)	March 12
Edward Marsh (96)	March 15
Nicholas Wittmayer (71)	March 18
Ermenio Mata (86)	March 18
Wilfred Otero (86)	March 24
Donald Sharp (84)	March 25
Alan Dickinson (74)	March 25
Clayton Henderson (95)	March 26
Wilbur McGuire (95)	March 26
Russel Dietzel (87)	March 28
George Arnot (91)	March 31
Alice Whitson (83)	April 5
John Long (73)	April 5
Harry Corcoran (77)	April 5
G. Drummond (88)	April 6
Marcelia Samuelson (89)	April 6
Charles Sain (87)	April 11
Clyde Seibel (79)	April 12
Richard Chavez (72)	April 12
James Guthrie (88)	April 17
Genova Johnson (90)	April 27
Erineo Jaramillo (92)	April 27
John Bell (79)	April 29
Garry Brown (73)	April 30
D. Raymond Hinds (87)	May 1

U.S. Representative Ben Ray Lujan visits Sandia's MESA Complex



PIPES IN PLAIN LANGUAGE — MESA Director Dave Sandison and Associate Labs Director Mike Burns explain to U.S. Rep. Ben Ray Lujan the complex infrastructure needed to support Sandia's Microsystems Engineering, Science and Applications capability that provides critical semiconductors for a variety of key Sandia missions, during the congressman's recent visit to Sandia. (Photo by Randy Montoya)

Raising the heat to lower the cost of solar energy

Sandia will compete to build a high temperature concentrating solar power pilot plant

By Kristen Meub

Sandia will receive $10.5 million from the Department of Energy to research and design a cheaper and more efficient solar energy system.

The work focuses on refining a specific type of utility-scale solar energy technology that uses mirrors to reflect and concentrate sunlight onto a receiver on a tower. The heat from the concentrated sunlight is absorbed by either a liquid, gas or solid and stored or used immediately in a heat exchanger to generate electricity. This type of energy, called concentrating solar power, is appealing because it can supply renewable energy — even when the sun is not shining — without using batteries for storage.

Current concentrating solar power systems can heat a substance to 565 degrees Celsius. The goal of this new project is to reach temperatures greater than 700 C, which would boost efficiency and lower the cost of electricity generated from concentrating solar power.

Sandia is leading one of three teams selected by the department's Solar Energy Technologies Office to compete to build a high temperature concentrating solar power system with built-in heat storage. Sandia's proposed system uses sand-like ceramic particles to absorb and store the heat from the concentrated sunlight. Sandia already has developed the world's first high-temperature falling particle receiver, and this research will refine and integrate that system into a complete pilot plant.

"We have demonstrated a prototype for the continuously circulating falling particles, and now we are adding six hours of storage, a 1-megawatt heat exchanger and a particle lift to demonstrate the entire thermal system," said Cliff Ho, Sandia's lead engineer on the project. "We believe particles are the best option for going to higher temperatures for advanced power cycles. The particles are inexpensive, durable and non-corrosive. They can be stored directly, they don't freeze and they can reach temperatures over 1,000 C."

Technologists John Kelton (retired), left, and Daniel Ray perform inspections of the falling-particle receiver during a cloud delay atop Sandia's National Solar Thermal Test Facility's Solar Tower. (Photo by Randy Montoya)

During the first phase of the two-year project, Sandia will design and evaluate the key components of its proposed pilot plant and work to mitigate risks associated with falling particle and concentrating solar power technology. Cliff said the team will focus on minimizing heat and particle losses from the receiver and identifying suitable designs for particle storage and a particle-to-working-fluid heat exchanger that will work for a large-scale power plant. The team will perform analyses to identify designs that meet both cost and performance goals for the Department of Energy.

During a second phase, the team will write a proposal that details the final concept for its proposed pilot plant. The DOE will also receive proposals from the two other teams and will choose one team to receive up to $25 million to construct and operate a pilot plant in the third phase of the program.

Sandia's project partners include the National Renewable Energy Laboratory, Georgia Institute of Technology, King Saud University, Saudi Electricity Company, Commonwealth Scientific and Industrial Research Organisation, University of Adelaide, Australian National University, the German Aerospace Center (DLR), Electric Power Research Institute, Solar Dynamics, SolarReserve, Carbo Ceramics, Solex Thermal Science, Vacuum Process Engineering, Allied Mineral Products and others.

Solar sedans join Sandia's fleet

By Kristen Meub
Photos by Rebecca Gustaf

Sandia drivers now have an emissions-free transportation option when they borrow from the Fleet Services loan pool — the power of the sun and three new electric cars.

In late May, Sandia installed a solar car charger and leased three plug-in electric Chevy Bolts from the General Services Administration. The charger, located on the west side of the Fleet Services lot near Thunderbird Cafeteria, fits in a parking space, can charge up to two electric vehicles at a time and can also charge electric carts. Each charge provides about 225 to 250 miles of clean driving. Sandia/California will get a second solar car charger soon.

"We wanted to bring plug-in electric vehicles to Sandia, and the solar charger was a cost-effective option for charging the cars," Mark Crawford, manager of Fleet Vehicles said. "These cars will replace our sedans over time."

The charger's solar panels track the position of the sun throughout the day to absorb as much solar energy as possible. Energy not needed immediately for charging is stored in a built-in battery, so the charger can provide solar-powered electricity at night and in the event of a power failure. The charger is built to be resilient and is rated to withstand 110 mph winds, earthquakes and hail of up to an inch in diameter.

The solar-charged Bolts will be available in the loan pool as soon as Fleet Services develops a short operating and safety guide.

CHARGING WITH SUN — Jeff Young charges a Chevy Bolt with Sandia's new solar-powered car charger.

SOLAR POWER FOR CARS — Sandia has a new sun-tracking solar panel car charger that can provide 100 percent emissions-free power for the fleet's electric vehicles.